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Implementation of biofuels in Malaysian transportation sector towards sustainable development: A case study of international cooperation between Malaysia and Japan

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ABSTRACT

Modern transportation nowadays has evolved into an important economic activity for human civilisation. Even though various alternative energy solutions have been put forward to reduce the dependency on fossil fuels, biofuels remain one of the few options which are capable of replacing the roles of fossil fuels in transportation sector without suffering from major economic losses. Malaysia with a huge supply of palm oil for biofuels production is intended to implement mandatory biodiesel blends in its transportation sector in 2011 in order to achieve its carbon reduction commitment towards a more sustainable development. This implementation was originally targeted to start in 2009 but had to be postponed due to several obstacles such as expensive cost, lack of sufficient infrastructure and low public demand. On the other hand, Japan is also trying to fulfil its carbon reduction obligation as outlined under Kyoto Protocol with the usage of biofuels to replace fossil fuels in the transportation sector. However, it lacks sufficient biofuels supply to support its high transportation energy demand. In this case study, the mutual cooperation between Malaysia and Japan in the implementation of biofuels in transportation sector will be studied and analysed in order to overcome the challenges presented in both countries. It is hope to ascertain potential cooperation opportunities amongst those two countries to promote biofuels energy as Malaysia is rich in natural resources whilst Japan has the relevant expertise and technology. It is believed that the strengths from one country can help to cover for the weaknesses from the other and vice versa via closer bilateral partnership which will be extremely crucial when dealing with global energy issues. Ultimately, it is hope that this case study will enable both Malaysian and Japanese government to achieve their renewable energy target in domestic transportation sector.

Contents

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1. Introduction

One of the most pressing global concerns in this century is none other than the issue of global warming. The dawn of the industrial revolution in Europe on the 18th century marked the beginning of huge emissions of carbon dioxide (CO_2) gases to the open atmosphere due to anthropogenic activities. Rapid accumulation of free CO_2 gases in our atmosphere will eventually lead to irreversible drastic climate change to our ecology. Over the years, several global climate talks had been conducted by United Nations and participated by more than 200 countries around the world [1]. Even though intense discussions and serious debates are still on-going at the moment, it is obvious that major carbon reduction scheme will be imminent in the near future to transform into low carbon society. Transportation sector accounted for almost 16% of the total global CO_2 emissions from man-made activities, just behind electricity generation and industry sector from manufacturing and construction [2]. A recent study regarding the influence of anthropogenic activities towards climate change had also proven that transportation sector would be the highest potential contributor to atmospheric warming in the near decades [3]. With regards to this, reducing net greenhouse gas (GHG) emissions in transportation has become one of the top priorities to achieve sustainable development.

Over the years, ample of alternative fuels such as biofuels, solar and fuel cell had been proposed to reduce the usage of non-renewable energy in transportation. Unfortunately, most of the renewable sources required radical technologies and revamping of the whole transportation energy supply system [4]. The changes might take more than several decades to be carried out and maybe even longer time to stabilise. In view of the critical time frame to address the increasing GHG emissions in transportation, biofuels remain as one of the most promising substitutions to replace fossil fuels in the transition phase towards cleaner transportation energy sources. Malaysia is one of the staunchest supporters in the Asia region to push for the implementation of biofuels in its transportation system. Regrettably, its progress is still far from success since it has encountered numerous problems along the way. Malaysia enjoys plentiful of natural resources to provide continuous supply for biofuels but lacks adequate skilled workforce and advanced technology [5]. As the whole world is gearing towards the implementation of biofuels in transportation sector, it is vital for Malaysia to identify the impending and subsequent challenges in order to stay at the forefront of sustainable development. In this context, Japan can serve as a perfect role model and ideal comparative case for Malaysia. As one of the most developed countries in Asia, Japan was able to reform its transportation industry with great success such as the introduction of 'Shinkansen' (bullet train) and hybrid vehicle [6]. Moreover, Japan possesses a rich pool of skilled workers and state-of-the-art green energy processing technology. Unfortunately, it does not have sufficient cost-effective supply of raw materials to cater for the biofuels demand for its transportation sector [7]. Therefore, in this case study, experience and government policies from both countries in revamping their transportation sector were studied extensively. Comparisons of scenario were made where appropriate and adapted to overcome the challenges in several key factors for the implementation of biofuels in their own respective native country. It was also hope that this review could pinpoint several opportunities for deeper cooperation amongst the two countries in order to achieve a win-win situation. Subsequently, the success based upon this symbiotical relationship may be able to serve as an example for other countries to emulate towards achieving the global quest for sustainable development in transportation sector.

2. Biofuels in transportation

In general, the term biofuel is used to represent all the liquid and gaseous transportation fuels derived predominantly from biomass [8]. Examples of biofuels include biodiesel, bioethanol, biomethanol, biohydrogen and bio-oil. Currently, biodiesel and bioethanol are the two most promising biofuels being projected to replace conventional fossil fuels in transportation. Biodiesel or fatty acid methyl ester (FAME) is normally synthesised through transesterification of vegetable oils with methanol and the aid of appropriate catalysts. It can be used to replace mineral diesel in compression-ignition (CI) engine which has almost similar properties without requiring any major engines modifications. Commercial production of biodiesel has been well established and is available to be purchased as turn-key plants in many countries [5]. On the other hand, bioethanol is suitable to replace the usage of gasoline in petrol engine. Conventional bioethanol is produced from the fermentation of simple sugar or starch crops. Its large-scale production has been well proven and demonstrated successfully in Brazil [9]. However, it competes with food sources for human consumption which renders it susceptible to criticisms. Another alternative raw material for bioethanol production is using inedible food sources mainly lignocellulosic material such as forest and agricultural biomass waste. However, additional pretreatment steps are normally required which will increase the overall production cost. Process optimisation is still being researched intensively at pilot plant scale in order to find a more cost-effective production method for mass commercialisation [10]. In this case study, biofuels for transportation in Malaysia and Japan will focus mainly on biodiesel produced from palm oil and Jatropha whilst bioethanol will be synthesised from lignocellulosic biomass. For Japan, majority of its source of biofuels is expected to be imported from Malaysia. Part of its demand for bioethanol will be fulfilled from its own agricultural and wood waste as well.

3. Malaysia vs Japan

Malaysia is a South East Asia country with total land area spans across 328,657 km^2 and inhibited with a population of more than 28 million people. After gaining independence from the British in 1957, Malaysia has successfully diversified its economy from natural resources and agricultural exportations to multi-sector output encompassing manufacturing, services and tourism. It is now one of the leading developing countries in the world with the aim to achieve the status of developed country by the year 2020. Malaysia enjoys a tropical climate with constant rainfalls throughout the year. This has enabled its plantation industry to thrive with agricultural products such as palm oil, rubber, cocoa and rice. Malaysia is also a net exporter of oil and gas and has thus benefited from the higher energy price. Almost 40% of its government revenue is derived from its local oil and gas producer, Petronas [11]. Unfortunately, its oil and gas reserves are fast depleting and adjustments will have to be made to curb the increasing demand for fossil fuels.

After World War II, Japan has successfully recovered and transformed into a global economic powerhouse. It is now the second largest economy in the world just behind the US. Part of its success can be attributed to a close working relationship and cooperation between the government and its private industry. Effective government policies such as the guarantee of lifetime employment for the urban workforce had enabled the private industry to flourish. In return, the private industry had developed a strong work ethic to drive the enhancement and progress of advanced technology [12]. Since Japan is heavily dependent on imported raw materials and fuels for its manufacturing sector, its state-of-the-art technology is pivotal in preserving its economy growth. As one of the largest oil

Table 1
Comparison of country data between Malaysia and Japan for the year 2009.

Country	Malaysia	Japan
Total area (thousand km^2)	329.8	377.9
Total arable land (thousand km^2)	75.9	47.4
Population (million)	28.3	126.8
Literacy (% of total population aged 15 and above)	88.7	99.0
GDP (USD billion)	388.8	4211.0
GDP per capita (USD thousand)	14.0	33.1
Labor force (million)	11.6	65.6
Unemployment rate (%)	3.7	5.1
Budget (USD billion)		
Revenue	49.7	1839.0
Expenditure	62.9	2252.0
Inflation rate (%)	0.6	−1.4
Export (USD billion)	157.5	545.3
Import (USD billion)	117.3	501.6
Oil production (thousand bbl/day)	693.7	132.7
Oil consumption (thousand bbl/day)	536.0	4363.0
Roadways (thousand km)		
Paved	80.3	961.4
Unpaved	18.4	242.4
Biofuels target		
Current	10% renewable energy	500 million litres of biofuels
Future	5% biodiesel blends by 2011	3600 million litres of biofuels by 2030
Carbon reduction target	40% of its CO_2 emission compare to 2005 level by 2020	25% of its CO_2 emission from 1990 level by 2020

and gas importers, Japan also suffers from the high energy prices and is exploring ways to reduce its dependency on fossil fuels. Some of the country data for Malaysia and Japan are listed in Table 1 for comparison purpose [11].

4. Current status

Since the introduction of Fifth Fuel Policy under the Eighth Malaysian Plan (2001–2005), Malaysia has been working to integrate renewable energy into its energy fuel mix. Transportation sector had the largest energy demand in the year 2000 with roughly 41% out of the total energy demand at 29.70 mtoe (million tonne of oil equivalent). Even though energy demand for industry had surpassed transportation in 2008 as the largest energy demand sector, transportation still recorded a considerable increase in energy demand up to 32.7% from 2000 within just an eight year span [13,14]. Despite the fact that ample of efforts had been put forward to rein in the escalation of energy demand, the annual increment was still being forecasted at about 3.5% average. Due to the excessive energy demand coupled with a large portion of its energy sources were still derived from fossil fuels, transportation remained as one of the largest GHG emitters in Malaysia. The emission was worsen due to the lack of proper public transportation infrastructure in Malaysia which has resulted in heavy reliance on passenger vehicles. Approximately 49% of the total GHG emissions can be attributed to transportation related activities [15]. The main types of fuels in transportation sector are shown in Fig. 1 [16]. Realising the over-reliance on fossil fuels, government of Malaysia had

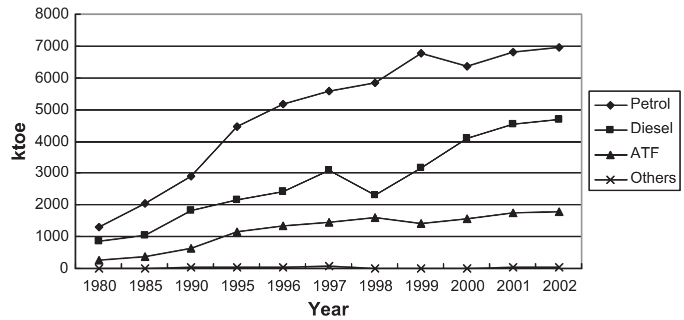


Fig. 1. Main types of fuels used in transportation sector in Malaysia from 1980 to 2002.

tried various holistic approaches to reduce their usages in order to fulfil the pledge made during the United Nations Climate Change Conference (UNFCCC) in Copenhagen 2009. The pledge stated that Malaysia will reduce as much as 40% of its CO_2 emissions by 2020 compares to the 2005 levels subjected to the financial assistance and technology transfer from developed countries. A large portion of the reduced carbon emissions is believed will be coming from the implementation of mandatory blending of B5 biodiesel (blending of 5% biodiesel and 95% mineral diesel) on June 2011 and bioethanol blend in the future. The preparation to embrace biofuels in Malaysia had started since 2005 when National Biofuel Policy was launched [5]. The policy was aimed to support the development of biofuels in Malaysia in order to reduce fuels import and promote palm oil as the primary commodity for biofuels production. Basically, this policy entails a four-prongs strategy which encompass producing a biodiesel fuel blend of 5% processed palm oil with 95% petroleum diesel, encouraging the use of biofuels amongst the public, which will involve giving out incentives for oil retail companies to provide biodiesel pumps at fuelling stations, establishing an industry standard for biodiesel quality, which will be the responsibility of Standards and Industrial Research Institute of Malaysia (SIRIM) and setting up of a palm oil biodiesel plant, which is targeted to be built in Labu, Negeri Sembilan. Under this policy, biofuels production is expected to increase by more than tenfold up to 2 million tonnes by 2010. Despite the strong Malaysian government's desire to push forward the usage of renewable energy in transportation industry, it is still faced with many uncertainties and experts believed that Malaysian biofuels future is still looking bleak. Currently, the usage of biofuels for domestic consumption still hovers below 0.1%.

In contrast, Japan's transportation sector already kick-started its transition to renewable energy last decade and is now at the full swing of exploring more cost-effective renewable transportation fuels [17]. As early as in the year of 2002, Biomass Nippon Strategy had been formulated as a key concept for promoting biomass utilisation in Japan. During the base years of 2002 through 2005, overall utilisation of waste biomass had increased from 68 to 72 percent (carbon equivalent) whilst the recycling rate of food waste improved nearly twofold. Riding on the back of this success, the Japanese Cabinet approved a revision of the Biomass Nippon Strategy on March 2006 with the view that it is of utmost important to promote the usage of biomass energy for transportation fuels. Several ministries had been identified to collaborate on Japan's biofuel policy which includes Ministry of Economy, Trade and Industry (METI), Ministry of Environment (MOE), Ministry of Education, Culture, Sports, Science and Technology (MEXT) and Ministry of Land, Infrastructure and Transport (MLIT). Substantial discussions and coordination amongst the ministries were done in Executive Committee on Biomass Nippon Strategy which was formed by director-general level officials of the ministries concerned. It set a goal to substitute fossil fuels with 500,000 kl (oil basis) of biofuels

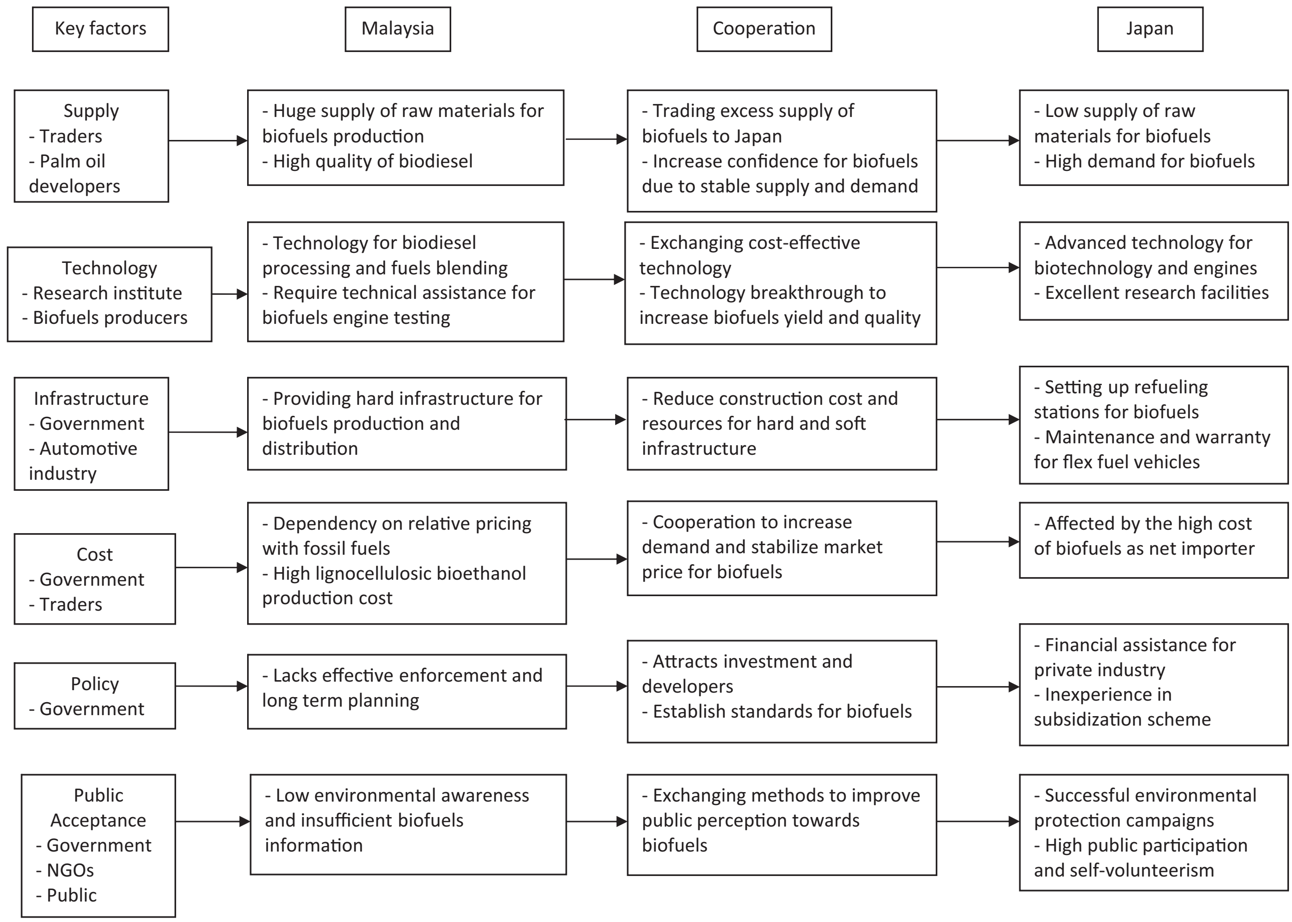


Fig. 2. Flow chart for the cooperation between Malaysia and Japan in each key factors and stakeholders.

for the transportation sector by 2010 [18]. Its pledge to become a low-carbon society underlined in the Proposal of the Council on the Global Warming Issue in 2008 has prompted more extensive efforts to promote the usage of biofuels in its transportation sector. Subsequently, by 2020, it hopes that the total biofuel percentage mix in transportation fuel can reach up to 10% with more than 40% of its road transportation using biofuels. Unfortunately, the transition progress is invariably hampered by the lack of supply of raw materials for the biofuels processing.

Diplomatic tie between Malaysia and Japan had been established back in 1957 and was further tightened when former prime minister of Malaysia, Dr Mahathir Mohamad implemented Malaysia's Look East Policy. The policy was specially designated for Malaysians to learn from the experience of Japan and Korea towards nation-building of Malaysia. Under this policy, many Malaysians were dispatched by the Malaysian government to study in Japan's universities and training institutions in order to emulate their remarkable ethics, morale and management. Consequently, Malaysia had succeeded in strengthening its cooperation with Japan in many areas such as economy, research academy and private industry. Realising the importance of energy security for both countries, a cooperation initiative for environment and energy was established in April 2010. Under this advanced cooperation, they will share information of activities regarding environment-related transport policies and forming a team of scientific researcher to address climate change issues through the usage of biofuels from biomass. Experiment study will be conducted on producing bioethanol from palm oil biomass and also offering training for human resources development for various new energy-related technologies and facilities through Malaysia-Japan University [19]. Industry cooperation in biofuels between both countries had also started in 2008 when a private Japanese company, Yanmar invested in a biodiesel research facility in Malaysia to perform research and analytical work for biodiesel fuel [5].

5. Key factors for implementation of biofuels

The success on the implementation of biofuels in the transportation sector is dependent on several key factors. In most of the cases, bilateral cooperation between Malaysia and Japan will be essential to accomplish the necessary preparations for the key factors with reduced time and resources. Fig. 2 provides a flow chart of the overall cooperation between the two countries and the details will be further discussed in the sections below.

5.1. Supply

Malaysia is the second largest producer of palm oil in the world just behind Indonesia. It produces more than 17 million tonnes of crude palm oil (CPO) annually from a total of 4.69 million hectares of palm oil plantations [5]. More than 88% of the total palm oil production is exported to countries such as EU, China, India and US due to higher prices and demand. The rest of the palm oil is either being processed into food products for local usage or biodiesel for foreign exportation. Meanwhile, in Japan, domestic supply of raw materials for biodiesel production will be rather limited. It consists of mainly small-scale rapeseed plantations and collection of waste cooking oil from households which only amount to about 0.5 million tonnes per year [20]. The amount of biodiesel required for the implementation of biodiesel blends for transportation fuels is shown in

Table 2
Biofuels statistics for the implementation of biofuels blends in road transportation.

Country	Mineral diesel consumption (ktoe)	Amount of biodiesel required (million tonnes)					Biodiesel available (million tonnes)
		B5	B10	B20	B50	B100	
Malaysia	5001	0.29	0.58	1.15	2.88	5.75	3.40
Japan	26,454	1.49	2.97	5.94	14.86	29.71	0.50
Total	31,455	1.78	3.55	7.09	17.74	35.46	3.90
Country	Mineral gasoline consumption (ktoe)	Amount of bioethanol required (million tonnes)					Bioethanol available (million tonnes)
		E5	E10	E20	E50	E100	
Malaysia	8136	0.38	0.76	1.52	3.80	7.61	9.20
Japan	43,429	2.03	4.06	8.12	20.30	40.61	1.03
Total	51,565	2.41	4.82	9.64	24.10	48.22	10.23

Table 2 [21]. Based on the current production volume and assuming that 80% of it was dedicated for food sources, Malaysia had sufficient supply of palm biodiesel to support up to B50 biodiesel blend [22]. However, Japan did not have enough biodiesel from its own domestic supply to support even the bare minimum of B5 biodiesel blend, which would require about 1.49 million tonne of biodiesel. At the same time, Malaysia had the potential to generate more than 104.55 million tonne of lignocellulosic biomass waste annually (including agricultural biomass and forest residues) [23]. These biomass are currently under-utilised by converting to solid fuels for heating or recycled fertilisers. Sources of bioethanol from Japan mainly originated from its domestic sugarcane plantations and other food-based energy crops (around 80%) whilst the rest was lignocellulosic based-feedstock (20%) [24]. From Table 2, it is obvious that bioethanol feedstock in Japan is only sufficient to support half of the biofuels demand if E5 bioethanol blend will be implemented.

Through mutual agreement, excess biofuels produced by Malaysia can be traded to Japan and enabled both parties to have enough supply for the implementation of B10 biodiesel blend and E20 bioethanol blend for transportation as depicted in Table 2. Lack of reliable biodiesel supply is one of the primary concerns after the mandatory biodiesel blend in transportation fuel is implemented in Japan. Currently, most of the domestic biodiesel fuels are supplied by small and medium producers which can only cater for a restricted group of users. Procurement of biodiesel from Malaysia can secure a reliable biodiesel supply over a long term to prepare for the imminent mandatory biodiesel blending in transportation fuels. A stable supply of biodiesel can effectively quash public's apprehension to embrace biodiesel as their choice of transportation fuel. Moreover, Malaysia has been able to produce high quality biodiesel consistently at optimised cost which meet the international standards for biodiesel (ASTM D 6571 and EN 14214). One of the most significant biodiesel variants from Malaysia is the winter grade palm biodiesel [5]. Conventional biodiesel is normally unsuitable to be operated in temperate countries such as Japan where the room temperature will often dip below its pour point at 15 °C especially during winter. Solidification and crystallisation will occur at colder temperature which can clog the diesel engine and reduce its efficiency. Winter grade palm biodiesel from Malaysia which is targeted for exportation to colder European countries, can withstand winter temperature from as low as −20 °C whilst retaining the same properties as normal palm biodiesel as shown in Table 3 [5]. Therefore, this type of biodiesel is suitable to be promoted to colder cities in Japan such as Sapporo, Hakodate and Kushiro. Apart from that, the shorter travelling distance between Malaysia and Japan (around 5300 km) compare to other biofuels trading countries can greatly reduce the exportation cost. The huge biofuels supply from Malaysia will also enable Japan to purchase in bulk and thus further reduce the cost due to economies of scale.

As calculated from Table 2, Malaysia's biofuels production is still far exceeding its own domestic demand even after the implementation of mandatory biofuels blending in transportation fuels. Currently, most of the biodiesel exportations from Malaysian are focused on European Union (EU) due to higher demand. However, over the years, several disputes had aroused which frustrated many of the Malaysian biodiesel exporters. First of all, exportation cost to European countries was quite high due to the long travelling distance from Malaysia. At the same time, it was also more susceptible to higher risks such as attacks by pirates and ship leakages. Secondly, most of the European countries possessed ample domestic sources of biofuels such as from rapeseeds, soybeans and corns. A large portion of their biofuels demand will be fulfilled by their own domestic biofuels whilst biofuels exported from Malaysia was used only to fill in the demand void created by insufficient raw materials. This political protective stance will create a sense of insecurity amongst biofuels exporters in Malaysia since the uptake was not consistent over a long term period. Apart from that, biofuels from Malaysia was also constantly under attacks by non-governmental environmental activists. They claimed that biofuels from Malaysia contributed negatively towards environmental sustainability since they catalysed the mass-clearing of rainforests for palm oil plantations. In addition, large conversion of palm oil into biofuels would jeopardise the global food security and supply [25]. As a result, EU had sanctioned tough sustainability criteria for its biofuels imports through Renewable Energy Directive (RED) which will come into effect on December 2010. It requires all biofuels to come from sustainable sources and have at least 35% GHG emission savings

Table 3
Comparison of the fuel characteristics for normal palm biodiesel and winter grade palm biodiesel.

Characteristics	Normal CPO methyl ester	Winter-grade CPO methyl ester
Ester Content (% mass)	98.5	98.0–99.5
Free glycerol (% mass)	<0.02	<0.02
Total glycerol (% mass)	<0.25	<0.25
Density at 15 °C (kg/L)	0.878	0.87–0.89
Viscosity at 40 °C (cSt)	4.4	4.0–5.0
Flash point (°C)	182	150–200
Cloud point (°C)	15.2	−18 to 0
Pour point (°C)	15	−21 to 0
Cold filter plugging point (°C)	15	−18 to 3
Sulfur content (% mass)	<0.001	<0.001
Carbon residue (% mass)	0.02	0.02–0.03
Cetane index	58.3	53.0–59.0
Acid value (mg KOH/g)	0.08	<0.3
Copper strip corrosion (3 h at 50 °C)	1a	1a
Gross heat of combustion (kJ/kg)	40,135	39,160

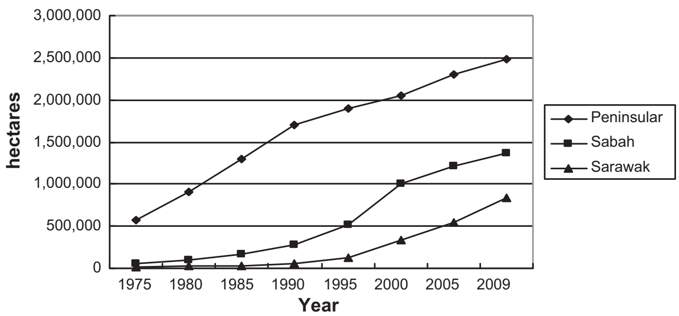


Fig. 3. Total area for palm oil plantation in Malaysia.

compare to fossil fuels [26]. Therefore, Japan can be a better destination for biofuels exporters from Malaysia compare to EU due to less stringent restrictions and more permanent demand. The shorter distance from Malaysia to Japan compare to EU will also help to reduce the extra cost for storage space by the biofuels exporters.

5.2. Technology

The advancement of technology in biofuels is extremely vital in order for them to become competitive with conventional fossil fuels. Basically, technology can play its role in three sections of the biofuels supply chain which are plantation, processing and end-usage. In palm oil plantation for biodiesel, the two most important criteria to be considered are the palm oil yield (in terms of fresh fruit bunch) and total plantation cost. One of the main difficulties of using palm biodiesel to replace mineral diesel is the restriction in supply. From Table 2 earlier, the amount of biodiesel produced was still far from enough to totally substitute mineral diesel in road transportation sector. It has to be kept in mind that the demand for transportation fuels will continue to increase due to increasing population overtime and rapid development. Hence, it will be almost impossible for the biodiesel supply to keep up with the demand since it is limited by the availability of land dedicated for palm oil plantations. In 2009, 4.69 million hectares of land had been dedicated to palm oil plantation which was about 61.8% from the total arable land in Malaysia. From Fig. 3, it is obvious that the expansion of palm oil plantation has been slowing down with the exception of Sarawak in the Borneo Island [27]. Further expansion of palm oil plantation will require encroachment into primary forests which will affect the sustainability of the natural flora and fauna. In this context, advanced technology will be much needed in order to increase the yield of palm oil per area of plantation. This can be achieved through intensive research in biotechnology, plant agronomy and precision agriculture techniques. At the same time, evolution of advanced technology will also enable palm oil to require lower inputs (fertilisers, pesticides, etc.) and thus help to drive down the overall plantation cost. Processing technology for palm biodiesel will involve the oil extraction and transesterification processes whilst for bioethanol from lignocellulosic biomass will be the pretreatment and fermentation processes. The former had been well established but still requires some optimisation. The latter is still in research phase and technology breakthrough will be needed for full commercialisation [8]. Technology for processing of biofuels will help to improve three primary areas which are processing cost, product yield and final product quality. The last part of the technology element will be beneficial for the end-usage of biofuels. End-usage of biofuels will involve blending and engine modification. Until now, it is still impractical to substitute 100% conventional transportation fuels from gasoline and diesel with biofuels. Therefore, blending of fossil fuels with a certain percentage of biofuels will need to be performed and relevant technology will be required to ensure the blending product meets the designated specifications. Even though biofuels still share a lot of similarities with conventional transportation fuels, a larger proportion of biofuels blending will still cause malfunction to the engines due to higher viscosity and lower energy density. Consequently, it is imperative to research the relevant technology to produce flexible-fuel vehicles (FFV) in order to accommodate larger proportion of biofuels blending and eventually be able to operate with 100% biofuels [28].

Technology cooperation between Japan and Malaysia will be crucial in order to ensure the success of the implementation of biofuels in transportation. Japan can provide the relevant technology and skilled workforce for the upstream process whilst Malaysia has the expertise and experience in the downstream process. Japan has been well-known for its advanced research and achievement in biotechnology. Owning to its limited arable land for plantations, Japan has highlighted the importance of biotechnology to aid its agricultural and bioremediation industry. A top government level Biotechnology Strategy Council headed by Japanese Prime Minister himself was set up in order to monitor the development of biotechnology in the country [29]. Currently, it has made significant breakthrough in biotechnology areas such as recombinant DNA, genetic engineering and gene analysis. These technologies can be applied to further increase the palm oil yield with fewer inputs after the successful decoding of palm oil genome by Malaysia [5]. Apart from that, Japan also possessed state-of-the-art research facilities which transformed it into the leading regional R&D centre in Asia. Their technology in the conversion of lignocellulosic biomass into bioethanol can help to optimise the processing cost and thus hasten the commercialisation of bioethanol production in Malaysia. Japan was also constantly staying at the forefront of engine manufacturing industry for road transportation. Toyota and Honda, two of the top largest Japanese automakers, had demonstrated their research capabilities by achieving high sales in their hybrid vehicles which can be powered by both fossil fuels and electricity [30]. Their experience in the study of hybrid engine for road transportation will be extremely useful for the modifications of internal combustion engine to accommodate larger proportion of biofuels in the future. For example, they can work together with Malaysia local automobile manufacturers, Proton and Perodua to develop FFV for both markets. On the other hand, Malaysia possesses technological advantage in the processing of biodiesel and blending of fossil fuels. Since 1980s, Malaysia had set up a specialised agency, Malaysian Palm Oil Board (MPOB) to coordinate the development and progress of palm oil in the country. Through years of intensive research, Malaysia's palm biodiesel processing was now one of the most cost-effective biodiesel production processes and had high demand in various countries. Its innovation had also enabled the commercialisation of novel palm biodiesel variants such as Envo Diesel (5% processed palm oil and 95% mineral diesel blend) and winter-grade biodiesel [5]. Unlike Japan, Malaysia is a net exporter of oil and gas which had rich experience in the blending of fossil fuels. This expertise can be used to aid the blending process of fossil fuels with biofuels. In overall, both Malaysia and Japan have their own strengths and weaknesses in dealing with the technology of biofuels supply chain. By encouraging technological exchange, research information transfer and exportation of skilled workforce, both sides will be able to advocate major breakthrough in the key energy technology areas and thus enjoy the full benefits with less hassle.

5.3. Infrastructure

Another key component for the success of the implementation of biofuels in transportation will be the establishment of both hard

and soft infrastructure. The relevant biofuels supply chain infrastructure will need to be convenient and sufficient to reach to the end-users for their daily usage. In terms of hard infrastructure, biofuels blending and refuelling station facilities will need to be set up adequately together with complete transportation of biofuels supply network. Whilst biofuels can make use of the existing fossil fuels supply network to a certain extent, it will be beneficial for biofuels to have their own independent supply chain. This is best to prevent any conflict of interest since biofuels and fossil fuels are competing products of each other. Moreover, it can help to identify possible difficulties for better planning in the future [31]. Blending facilities will have to be in minimum distance from both conventional oil and gas refineries and biofuels processing facilities in order to minimise the transportation cost. Existing refuelling stations will need to be supplied with biofuels blends and equipped with necessary modifications. New refuelling stations dedicated for biofuels blends will also need to be constructed at other strategic locations in order to gain access to a larger population. New building constructions should be minimal since most of the urban areas nowadays have been saturated with refuelling stations which should eliminate the extra cost for the transition of transportation fuels to biofuels. Soft infrastructure is equally important in order to catalyst the smooth transition of transportation fuels to biofuels. Soft infrastructure will encompass the training of skilled workforce, warranty from the engine manufacturers for the usage of biofuels blends and maintenance or technical support. Each party including workers, sellers and contractors in the transportation sector will need to adapt to the imminent changes after the introduction of biofuels so that they will be able to response to any relevant incident which might occur. Warranty of engines for biofuels usage and necessary technical support will assure the mass public pertaining to the safety issues and thus encourage more early adopters for biofuels blends.

Japan had rich experience and valuable knowledge for the preparation of new refuelling station and its strategic placement. Back in 2005, Japan had already started its own Japan Hydrogen and Fuel Cell (JHFC) Project to promote the usage of hydrogen as a cleaner transportation fuel. Under this project, twelve hydrogen refuelling stations had been built in eleven cities in Japan to form Japan Hydrogen Highway. Further expansion of the highway was planned to be rolled out by the year 2015. Japan's experience in setting up sufficient refuelling stations for hydrogen fuel cell can certainly be applied during the implementation of biofuels blends as transportation fuels [32]. Their invaluable understanding towards accessing the supply, demand, technical difficulties and risks will certainly be beneficial to Malaysia. In addition, Japanese automaker powerhouses such as Toyota and Honda possessed leading technology in the manufacturing and modification of internal combustion engine for road vehicles. They will have the know-how technology to provide maintenance or technical assistance to the FFV engines operating on biofuels blends. Previously, implementation of biofuels blends in Malaysia had suffered setback due to the unwillingness of engine manufacturers to cover for the warranty of Envodiesel usage in the engine. Most of them cited the high risks associated with the combustion of biofuels blends inside CI engine which might lead to its premature failure [33]. Moreover, there was insufficient compelling scientific evidence and further testing was not able to be performed due to lack of technology and skills. By cooperating with Japan, Malaysia's engine manufacturers will be able to make use of their state-of-the-art research centre to identify with greater precision the degree of risks involved and subsequently provide reasonable warranty to cover for the future usage of biofuels blends in diesel and gasoline engines.

On the other hand, Malaysia had top-notch fuels blending facilities and also be able to offer training of skilled workers in biodiesel [34]. Malaysia's oil fields possessed one of the highest grades of petroleum in the world called tapis oil which is used as a reference for light Far East oil. It is one of the lightest and sweetest crude oil with little impurities and can fetch a higher crude oil price in the international energy market. Therefore, it is often being used to blend with other lower grade crude oil in order to produce petroleum products which meet the minimum international standards. Currently, Malaysia has 6 oil and gas refineries with adequate blending facilities to support oil production up to 515,000 bbl/day. In view of this, blending facilities for biofuels blends can easily be carried out in the current established premises with minimal modification. This can again help to reduce the budget for additional construction cost. The experience from Malaysia in troubleshooting the biofuels blending facilities can be of great use during the construction of similar facilities in Japan later on. Furthermore, preparation of sufficient pool of skilled workers can be achieved under the cross-exchange training program organised by both countries. Skilled workers from Japan can be trained under the various palm biodiesel workshops and seminars organised by MPOB whilst trainees from Malaysia can learn the relevant lignocellulosic bioethanol production techniques in Japan. In general, extended cooperation between the two countries in preparation for the infrastructure for biofuels blends can help to reduce costs, efficient resources pooling and less time-consuming.

5.4. Cost

One of the biggest obstacles for the implementation of biofuels blends in transportation is their higher cost relative to conventional transportation fuels. Road transportation had already become one of the most basic needs for human civilisation to perform their daily activities. Besides providing a convenient way for commuters to travel from one place to another, it is also being employed as an important way to transport goods and services. Modern transportation had been closely linked to a country's growth in GDP (Gross Domestic Product) and had huge impact on its economy and society. Recently, the rising cost of fossil fuels has resulted in the need for net oil importer countries to readjust transportation fuel retail prices especially for diesel and gasoline. The rising cost of transportation fuels might trigger high inflation and raising living cost due to its huge implications in many economy activities. It has become a political sensitive issue and in some countries, such as Indonesia, may incite public riots [5]. Even though production technologies for biofuels have been long established, their commercialisation are often delayed whilst for some being shelved off completely due to exorbitant production cost [8]. The same situation applies to the implementation of biofuels blends in transportation sector. As shown in Table 4, the end-user pump price for both biodiesel and bioethanol are still higher than conventional mineral diesel and gasoline [35]. From Fig. 4 which shows the break-even line for biodiesel with diesel in relation to price of crude oil and crude palm oil (CPO), it can be seen that for crude oil hovering at USD 90/bbl, the maximum of price CPO must be

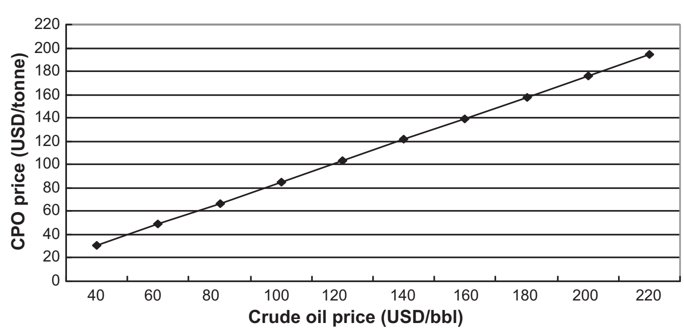


Fig. 4. Break-even cost for biodiesel in relation to price of CPO vs crude oil.

Table 4
Comparison of pump price cost breakdown for fossil fuels and biofuels in Malaysia.

Cost (US cent per litre)	Subsidised diesel	Palm biodiesel	Subsidised gasoline	Lignocellulosic bioethanol
Raw material	56.61[a]	64.56[b]	56.61[a]	21.46[c]
Production	3.70	6.67	2.06	40.29
Distribution	4.23	4.23	4.23	4.23
Subsidy/Investment	−0.17	–	−0.17	+19.14
End-user pump price	64.37	75.46	62.73	85.12

[a] Based on crude oil price at USD 90/bbl.
[b] Based on CPO price at USD 750/tonne.
[c] Estimated from the collection and transportation cost.

around USD 70/bbl or USD 495/tonne for biodiesel to be cost competitive. However average pricing of CPO for the year 2010 was around USD 725/tonne which was almost 50% higher than the maximum tolerance. Lignocellulosic bioethanol was also calculated to be economically feasible only when crude oil prices is above USD 126/bbl. Moreover, many countries had been practicing their own subsidy scheme for transportation fuels in order for their citizens to purchase them at a less costly price. Malaysia for example, was giving out approximately 0.17 US cents per litre for diesel and gasoline. Subsidisation of transportation fuels will further increase the economy gap between conventional fossil fuels and biofuels as transportation fuels.

Cooperation between Malaysia and Japan to implement mandatory blending of biofuels in transportation sector can greatly reduce the overall cost and thus becomes more economically viable for the free market without any subsidisation. Their partnership to improve areas such as plantations, supply infrastructure and technology through information exchanging and resources pooling can greatly optimise the whole supply chain. As seen in Table 4, the main contribution to the cost of pump price for biodiesel is the price of CPO which stands at over 80% from the overall cost. Currently, the latest price for CPO was around USD 814/tonne and was expected to increase further in the year 2011. The increment in CPO pricing was mainly due to the increasing demand to a record level for food and biodiesel production. Growing world population had increased the demand for palm oil related food products in many countries around the globe. Escalating demand for clean energy due to decision to phase out fossil fuels also increased the demand for palm biodiesel. In addition, low supply of its competing products such as corn and soybean oil due to adverse weather conditions also resulted in popular demand for palm oil. One of the feasible ways to maintain the pricing of CPO at a reasonable level will be to increase its supply. Cooperation with Japan will allow Malaysian palm oil developers to adopt more advanced plantation techniques and skills in order to increase the average palm oil yield with lesser requirement for fertilisers and pesticides. With the aid of biotechnology, it is possible to increase the current palm oil yield to more than two-fold with the same acreage [5]. The increasing production of biofuels will also lower the processing cost due to larger economies of scale. The fact that biofuels can make use of the existing infrastructure and energy supply system greatly reduced the initial capital investment needed, which the rest can then be easily co-funded by both countries. Improvement in processing technology for biofuels due to the R&D collaboration between two countries was estimated to further reduce the cost by 20–30% for biodiesel and 50–60% for lignocellulosic bioethanol [36–38]. Apart from that, biofuels was also eligible to apply for the carbon credit through Clean Development Mechanism (CDM) formed under Kyoto Protocol. Through this scheme, certified carbon emission reductions from a developing country can be traded for a certain monetary value in a carbon market to a developed country in order to reduce their own carbon footprints. In this context, through the production and usage of biofuels, certified carbon emission reductions from Malaysia can be traded to Japan to help achieve Japan's carbon reduction target. On the other hand, Japan will provide financial assistance according to the CDM as credit to reduce the overall biofuels cost. It was estimated that carbon trading could help to provide rebate about 0.50–3.00 cents per litre of biofuels [31]. The cumulative effect from all the factors above will render the pump price for biofuels to be more competitive to fossil fuels especially since the subsidy for fossil fuels will be eventually removed in the future.

5.5. Policy

Government's intervention in the introduction and promotion of any social and economy changes was pivotal to ensure its success and stability for the long term. Inefficient government enforcement and support are widely believed to be one of the reasons which lead to weak domestic demand. Government as the critical stakeholder in the implementation of biofuels blends for transportation sector will be responsible to stage a suitable platform or medium for other stakeholders such as industry players, non-governmental organisations (NGO), research institutes and private investors to contribute towards the development of the biofuels blends. Through adequate official policies and firm directives on the subject, it will be able to attract huge interests from the relevant stakeholders whilst still allowing the flexibility to coordinate crucial activities so as not to derail from the main objectives of the implementation. In this context, government policies will be critical in areas such as subsidisation scheme, tax relief, financial assistance, information dissemination, investment environment, authorisation and standards of biofuels blends. Currently, biofuels industry is still in its infancy stage in both Malaysia and Japan [5,7]. Despite numerous calls by the Malaysian government to substitute fossil fuels with biofuels to move towards a low carbon society, the progress in the private sector remained slow and the feedbacks were largely indifferent. This was understandable since biofuels industry was still associated with high economic and technical risks. In addition, local demand is low and most of the supply chain infrastructures are not ready yet. Thus, venturing into biofuels industry at this early stage would not justify with their economic interests which will require a longer capital payback period. Previously, increasing environmental awareness had fuelled the demand for biofuels such as biodiesel and plenty of biodiesel plants were constructed. However, when the price of crude oil plummeted to about USD 30/bbl, expensive biodiesel was unable to compete with mineral diesel and thus rendered its demand to drop substantially. Consequently, most of the biodiesel plants were either being shut down or forced to cut down their production [5,39]. Future policy makers will need to address the above shortcomings and prevent the history from repeating itself. Implementation of various supporting policies to assist new and existing biodiesel entrepreneurs will help to rebuild their confidence and encourage more participants to commit themselves to the biofuels industry.

As stated earlier, implementation of effective policies will be fundamental to ensure the smooth transition of fossil fuels to biofuels in the transportation sector. However, drafting of seamless

policies will be very tedious and requires proper planning and ample of experience. Therefore, it will be crucial for Malaysia and Japan to cooperate and learn from each other to ensure the efficiency of the policies implemented and review them from time to time. Japan can be an excellent role model for policies related to investments and financial assistance. As the second largest economy in the world, Japan had successfully attracted a huge inflow of foreign direct investment (FDI) into its country due to ample of perks provided through its liberalised free market policies. It had managed to establish a competitive and rewarding investment environment for its industry to prosper which in turn enabled the emerging of many Japanese international companies such as Toyota, Sony, and Canon. It is hope that through the similar policies, Malaysia will also be able to produce their own highly competitive international biofuels companies which were able to sustain on their own without relying on government's support. Apart from that, Malaysia can also learn from Japan for its outstanding government policies in supporting R&D in biofuels through various systematic channels and grants. Japanese policies in its academia have managed to produce ample of world-renowned scientists with many groundbreaking discoveries. Their experience will certainly be helpful for Malaysia to further strengthen its R&D in biofuels to catalyst their development in the future. Besides, Malaysia and Japan can also cooperate to establish their own standards of biofuels for usage in transportation sector. Currently international standards for biofuels mainly follow the guidelines set by western countries such as EU and US [40]. However, the quality of biofuels, climate conditions and transportation system in eastern countries are largely different from them. Therefore, adjusting biofuels standards for local usage will be essential to promote higher acceptance amongst local population. Through the combination of Malaysia's biofuels quality and Japan's engine specifications, a more appropriate standard of biofuels for transportation sector in Asia region can be enacted. On the other hand, Japan can revise the subsidy policy in Malaysia for fossil fuels and employed it to promote biofuels usage in its own country especially during the early stage. Malaysia had set up its own subsidisation scheme for controlled items such as fuels, sugars and cooking oil in a bid to reduce the burden of their citizens. Whilst subsidisation policy in a long run will be detrimental, it can actually be very effective to promote usage of biofuels during the initial transition period. It was even more significant for Japan since the biofuels were also under intense competition from other renewable energies such as fuel cell and solar.

5.6. Public acceptance

Public acceptance for biofuels will be the last challenge to be addressed once all the relevant infrastructures and supply system are in place. Since mass public is the major user of fossil fuels in transportation sector, their willingness to switch to biofuels blends is important to ensure the success of the implementation. Lack of public support for new transportation fuels can eventually lead to catastrophic failure as already seen in the case of natural gas in Canada and New Zealand [41]. Their reluctance to adopt new transportation fuels were usually originated from their lack of confidence and information pertaining to the radical changes which might take them by surprise. Low uptakes amongst the public can snowball into a chain reaction with refuelling station operators refusing to sell or store biofuels due to low demand. This will then further reduce the uptakes of biofuels due to insufficient refuelling stations. Whilst mandatory biofuels blends can force the public to make the switch, it was extremely important that they were being given sufficient information pertaining to the changes. Many of the citizens in developing countries such as Malaysia had low environmental awareness and are not familiar with the operation of biofuels. They generally adopt a lackadaisical attitude in giving positive feedbacks to the biofuels campaign in Malaysia. Things will get complicated due to the confusion especially when they might need to absorb the additional transportation cost due to more expensive biofuels. This can lead to possible public unrest and protest which will eventually tarnish the image of biofuels. In view of this, it will be crucial to disseminate information regarding the benefits and risks to the public beforehand through various mass media and communication channels for them to understand the objectives behind the implementation of biofuels in transportation sector.

Currently, less than 1% of the biodiesel production in Malaysia is allocated for local consumption and most of it is limited to government's vehicle. There is almost zero biodiesel usage in the private sector as well as for the public. Implementation of mandatory biofuels blends should therefore be carried out in stages starting with the urban areas before spreading it to the rural areas. In order to achieve a higher biofuels penetration for the smooth transition, public's perspective towards biofuels will first need to be amended so that they will view them positively. In this case, Malaysia can emulate the fine example done in Kyoto City by Japan. Ever since being selected as an environmental model city by Japanese government in January 2009, Kyoto City had transformed into one of the leading cities in the world to spearhead the movement to reduce carbon emissions. Through extensive campaigns, promotions and publicity, many of its citizens were now aware of their responsibilities to maintain a low carbon society through practices in their daily activities and lifestyles. Numerous measures such as forest conservation, green buildings and industries decarbonation have been implemented with great success due to the positive response and self-volunteerism from its public [42]. This had enabled the city to set up ambitious carbon reduction projects such as the Kyoto City Global Warming Countermeasure Ordinance to pursue reduction of GHG by 40% compared to 1990 level by 2030. Cooperation with Japan will allow Malaysia to study the success model of Kyoto City in order to increase its citizens' knowledge for biofuels. It was hope that their understanding towards the purposes of biofuels will eliminate their resistance towards the changes. On the other hand, higher public acceptance for biofuels in Malaysia will bring higher demand which can help to spur on faster development of biofuels. This will indirectly help to attract higher interest for biofuels in Japan and thus achieve another win-win situation.

6. Recommendations

Although implementation of biofuels blends in transportation sector will be more imminent in the future, adequate preparation as discussed above must be ready beforehand in order to prevent more obstacles from ruining the project. Over-rushing to implement biofuels blends will only backfire without the support of the necessary hard and soft infrastructure. Malaysian government's hasty decision to implement biofuels blends in 2009 was in the end stagnated due to lack of sufficient support and had to be postponed to 2011. The failure to implement the project in the timeframe as scheduled will definitely draw doubts from various quarters and eventually reduce public's confidence over the feasibility of biofuels blends. Therefore, it is imperative for Malaysia to team up with a strategic partner such as Japan to accelerate the development of the necessary key factors for the implementation of biofuels. In order for both parties to gain the maximum benefits from this mutually inclusive relationship, adequate communications and interactions between them will be very crucial. Whilst it is true that the cultures and practices in Malaysia and Japan are vastly different, intimate cooperation can still be formed by setting up appropriate communication channels to build up mutual trust amongst each other. In general, there can be three levels of communications

to be established which are government, industry and academia. For the government level, official visits or observation trips by energy and transportation officials can be arranged to study and experience the effect of policies promoted by the other country. Meanwhile, for the industry level, business cooperation in terms of co-investment, joint venture, merger and acquisition can serve as a linkage for biofuels companies in both countries to communicate and explore more business opportunities together. Trade fairs and business forum should be organised periodically for biofuels industry players from both countries to serve the communication purpose. As for the academia, scientists and researchers from both countries can frequently exchange scientific data and information from their experimental progress. Through extensive discussions and debates in academia conferences or technical workshops, they will be able to keep abreast with the latest biofuels development and prevent from repeating each other research work. The plan to set up a joint Malaysia-Japan University (MAJU) will enable access to higher degree of communications from both sides.

7. Conclusions

Implementation of biofuels in transportation sector marks an important milestone in the course of phasing out fossil fuels with renewable energy. If it is successful, it can discard the belief that fossil fuels are irreplaceable and thus pave the way for the introduction of other more radical renewable energy such as fuel cell and solar energy in the future. As it stands now, biodiesel blends is already in place to replace part of the mineral diesel demand in transportation sector. Future work will focus on optimising the production cost and increasing the palm oil yield in order to support higher biodiesel blending percentage in the blends. Moreover, demand for diesel is widely predicted to have higher increment in the future since more automakers will focus on diesel-powered automobiles due to their higher combustion efficiency. On the other hand, lignocellulosic bioethanol still requires extensive research to make it viable for gasoline replacement. Currently, its production is still too complicated compare to conventional sugar and starch crops bioethanol. Establishing commercial production of bioethanol will be equally important since most of the current private transportation vehicles are operated using gasoline. The initial success of the implementation of biodiesel blends will to a greater extend help to spur the advancement of lignocellulosic bioethanol in the longer term. International cooperation will be more and more important in dealing with global issues such as renewable energy and can be very advantageous as discussed in the work above. The successful partnership between Malaysia and Japan can be a good role model for other countries to emulate in the future.

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References

[1] UNFCCC (United Nations Framework Convention on Climate Change). COP 16/CMP 6, Cancun, Mexico, <http://unfccc.int/2860.php>; 2010.
[2] OICA (International Organization of Motor Vehicle Manufacturers). Climate change and CO_2, <http://www.oica.net>; 2008.
[3] Unger N, Bond TC, Wang JS, Koch DM, Menon S, Shindell DT, et al. Attribution of climate forcing to economic sectors. Proceedings of the National Academy of Sciences of the United States of America 2010;107(8):3382–7.
[4] Van den Hoed R. Sources of radical technological innovation: the emergence of fuel cell technology in the automotive industry. Journal of Cleaner Production 2007;15(11–12):1014–21.
[5] Lim S, Teong LK. Recent trends, opportunities and challenges of biodiesel in Malaysia: an overview. Renewable and Sustainable Energy Reviews 2010;14(3):938–54.
[6] Horihata K, Sakamoto H, Kitabayashi H, Ishikawa A. Environmentally friendly railway-car technology. Hitachi Review 2008;57(1):18–22.
[7] IEEJ (The Institute of Energy Economics Japan). Japan's ethanol introduction and outstanding issues, <http://eneken.ieej.or.jp/en/data/pdf/40.pdf>; 2007.
[8] Demirbas A. Progress and recent trends in biofuels. Progress in Energy and Combustion Science 2007;33(1):1–18.
[9] Pacini H, Silveira S. Consumer choice between ethanol and gasoline: Lessons from Brazil and Sweden. Energy Policy 2011;39(11):6936–42.
[10] López-Arenas T, Rathi P, Ramírez-Jiménez E, Sales-Cruz M. Acid pretreatment of lignocellulosic biomass: steady state and dynamic analysis. Paper presented at the Chemical Engineering Transactions 21:2010;445–50.
[11] CIA (Central Intelligence Agency). The world factbook, <https://www.cia.gov/library/publications/the-world-factbook/index.html>; 2010.
[12] Watanabe C, Shin J-H, Heikkinen J, Zhao W, Griffy-Brown C. New functionality development through follower substitution for a leader in open innovation. Technological Forecasting and Social Change 2011;78(1):116–31.
[13] Ahmad N. Pursuing a better energy sector, policy perspective. The Star Online, <http://biz.thestar.com.my/news/story.asp?file=/2010/3/22/business/5901485&sec=business>; 2010.
[14] Hassan MHJ, Karim MR, Mahlia TMI. Energy use in the transportation sector in Malaysia. Malaysian-Danish Environmental Cooperation Programme, <http://www.scribd.com/doc/10049213/Energy-Use-in-the-Transportation-Sector-of-Malaysia>; 2005.
[15] MOSTE. J. Malaysia initial national communication. Kuala Lumpur, Malaysia: Ministry of Science, Technology and Environment; 2000.
[16] National Energy Balance 2002. Ministry of Energy, Communications and Multimedia, Kuala Lumpur, Malaysia; 2003.
[17] Lau LC, Tan KT, Lee KT, Mohamed AR. A comparative study on the energy policies in Japan and Malaysia in fulfilling their nations' obligations towards the Kyoto Protocol. Energy Policy 2009;37(11):4771–8.
[18] Kuzuhara Y. Biomass nippon strategy—why biomass nippon now? Biomass and Bioenergy 2005;29(5):331–5.
[19] MOFA (Ministry of Foreign Affairs Japan). Japan-Malaysia Cooperation Initiative for Environment and Energy, <http://www.mofa.go.jp/region/asia-paci/malaysia/pdfs/environ-energy1004.pdf>; 2010.
[20] Harumi H, Yu N. Japan's biodiesel fuel introduction. Japan: The Institute of Energy Economics; 2008.
[21] TradingEconomics. Road sector diesel fuel consumption (kt of oil equivalent) in Malaysia, <http://www.tradingeconomics.com/malaysia>; 2010.
[22] World Growth Palm oil and food security: The impediment of food supply, <http://www.worldgrowth.org/assets/files/WG_Food_Security_Report_12_10%281%29.pdf>; 2010.
[23] Goh CS, Tan KT, Lee KT, Bhatia S. Bio-ethanol from lignocellulose: status, perspectives and challenges in Malaysia. Bioresource Technology 2010;101(13):4834–41.
[24] Matsuoka M. Sugarcane cultivation and sugar industry in Japan. Sugar Technology 2006;8(1):3–9.
[25] Gui MM, Lee KT, Bhatia S. Feasibility of edible oil vs. non-edible oil vs. waste edible oil as biodiesel feedstock. Energy 2008;33(11):1646–53.
[26] Wahid MB, Shariff FM, Balu N, Ismail N. EU's renewable energy directive: possible implications on Malaysian palm oil trade. Oil Palm Industry Economic Journal 2008;8(2):1–7.
[27] MPOB (Malaysian Palm Oil Board). Planted area and yield 2009, <http://econ.mpob.gov.my/economy/annual/stat2009/ie_tajuk-AREA.htm>; 2009.
[28] Jayed MH, Masjuki HH, Kalam MA, Mahlia TMI, Husnawan M, Liaquat AM. Prospects of dedicated biodiesel engine vehicles in Malaysia and Indonesia. Renewable and Sustainable Energy Reviews 2011;15(1):220–35.
[29] Kong SK. The competitiveness of biotechnology in Japan. International Journal of Biotechnology 2001;3(1–2):184–98.
[30] Müller H-E. Supplier integration: an international comparison of supplier and automaker experiences. International Journal of Automotive Technology and Management 2009;9(1):18–39.
[31] Kojima M, Johnson T. Biofuels for transport in developing countries: socioeconomic considerations. Energy for Sustainable Development 2006;10(2):59–66.
[32] Sakata K, Mizutani E, Fukuda K. A review of topics in hydrogen-related innovative materials in Japan. Journal of Power Sources 2006;159:100–6.
[33] Basiron Y. Pushing the case for Envodiesel. Palm oil truth foundation, <http://www.palmoiltruthfoundation.com/index.php?option=com_content&task=view&id=35&Itemid=57>; 2006.
[34] Lau H, Kok Y, Choo Y. Effects of nanotag markers in palm methyl esters and their blends with petroleum diesel. Journal of the American Oil Chemists' Society 2010;1–7.
[35] Trummer DR. Biofuels for the Malaysian Transport Sector. Renewable energy and energy efficiency component. Malaysian-Danish Environmental Cooperation Programme; 2006.
[36] Obando DS, Gualdrón MA, Reno MLG, Lora EES. Techno-economic indicators for the thermochemical and biochemical routes for biofuels production using sugarcane bagasse as feedstock. Zuckerindustrie 2010;135(10):601–6.

[37] Soldatos P, Lychnaras V, Panoutsou C, Cosentino SL. Economic viability of energy crops in the EU: the farmer's point of view. Biofuels, Bioproducts and Biorefining 2010;4(6):637–57.
[38] Torchio MF, Santarelli MG. Energy, environmental and economic comparison of different powertrain/fuel options using well-to-wheels assessment, energy and external costs – European market analysis. Energy 2010;35(10): 4156–71.
[39] Abdullah AZ, Salamatinia B, Mootabadi H, Bhatia S. Current status and policies on biodiesel industry in Malaysia as the world's leading producer of palm oil. Energy Policy 2009;37(12):5440–8.
[40] Trindade SC. The sustainability of biofuels depends on international trade. Energy Sources, Part A: Recovery, Utilization and Environmental Effects 2009;31(18):1680–6.
[41] Flynn PC. Commercializing an alternate vehicle fuel: lessons learned from natural gas for vehicles. Energy Policy 2002;30(7):613–9.
[42] Gomi K, Ochi Y, Matsuoka Y. A concrete roadmap toward a low-carbon society in case of Kyoto City. Journal of Renewable and Sustainable Energy 2010;2(3):1–21.